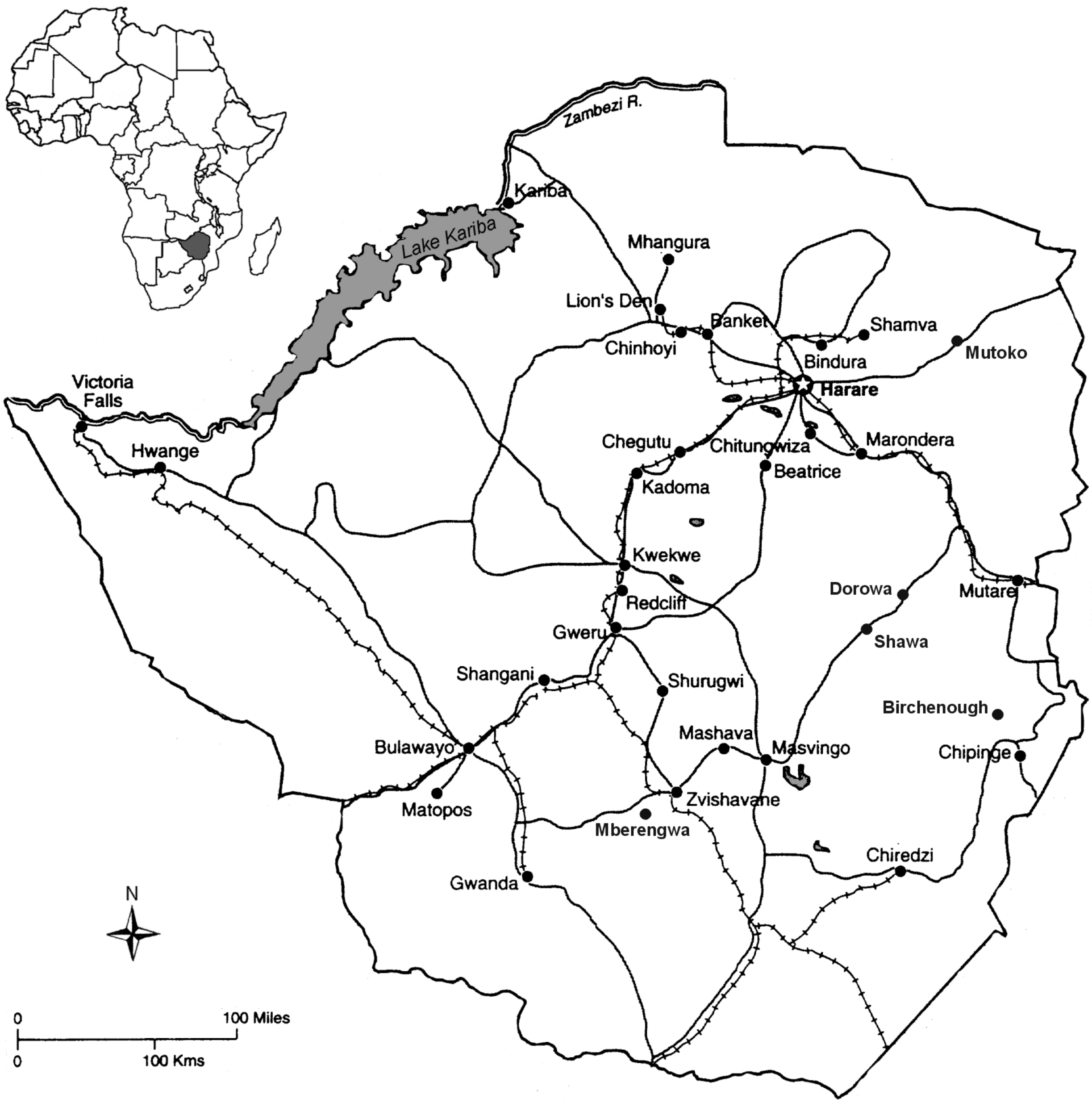
Zimbabwe

Total population (July 2000 estimate): 11,343,000
Area: 390,580 km^2
Annual population growth rate (2000): 0.26%
Life expectancy at birth (1998): 43.5 years
People not expected to survive to age 40 (1998): 41% of the total population
GDP per capita (1998): US $2,669



Zimbabwe is a landlocked country in central southern Africa, located between the Zambezi River and the Limpopo River. The landscape in the centre of the country is a gently rolling highland. Hot and dry lowlands occupy the southeast of Zimbabwe, as well as the Zambezi valley in the north. An extensive flat area covered with aeolian sands of the Kalahari marks the landscape in the west of the country. A series of mountain ranges straddle along the border with Mozambique.

Modern mining and farming activities are important to the economy of Zimbabwe. Over 40 minerals are mined in Zimbabwe, some of which are processed in the country to provide added value. Mineral production is dominated by gold, followed by asbestos, nickel, chromium and coal. The dimension stone industry, especially the extraction of 'black granite' is expanding rapidly. Trans-national companies operate many of the major mines while nationals largely run small mines. Small-scale artisanal gold mining has attracted many people, especially during times of economic hardship. The International Labour Organization (1999) estimated that between 50,000 and 350,000 persons are involved in small-scale mining in Zimbabwe.

The agricultural sector, which accounted for 20% of the GDP in 1999 and employed approximately 27% of the working population, is divided into large-scale commercial farming and agricultural production in so-called 'communal areas.' The commercial farming sector produces maize, tobacco, and cotton, as well as livestock. Small-scale subsistence farming is practised mainly in the impoverished 'communal areas' with maize, sorghum and vegetables being the principal crops.

Most of the soils in Zimbabwe are nutrient deficient and are degrading at a rapid rate. Large portions of Zimbabwe's soils are derived from granitic parent materials with nutrient-deficient sandy soils and low organic matter contents (Nyamapfene 1991). The soils with 'greenstones,' as parent material have a much higher inherent soil fertility. Zimbabwe's soils are continuously cropped but nutrient removal through harvesting without sufficient nutrient replenishment leads to a continuing decline in soil fertility. The two main limiting nutrients on Zimbabwe's soils are nitrogen and phosphorus.

Geological outline

Zimbabwe consists predominantly of Precambrian rocks, which can be divided into several units:

- the Archean granite/greenstones,
- the Archean Limpopo mobile belt,
- the Paleoproterozoic Umkondo and Lomagundi Group,
- the Neoproterozoic Makuti, Rushinga and Sijarira Groups.

Archean granites and greenstones of the Zimbabwe Craton cover about half of Zimbabwe and form the central part of the country. The Archean Limpopo mobile belt, located between the Zimbabwe and Kapvaal Cratons in the south, is characterized by high-grade metamorphic rocks that have undergone poly-phase deformation. The linear Great Dyke, one of the longest mafic and ultramafic layered intrusion in the world, crosses the country for about 550 km in a north-northeasterly direction. It varies in width from 4 km to 12 km. The age of the Great Dyke is 2,586 ±16 million years (Mukasa *et al.* 1998). The Paleoproterozoic low-grade metasediments of the Umkondo Group are exposed in the east-southeast of Zimbabwe along the border with Mozambique. The folded and metamorphosed Lomagundi Group covers extensive areas northwest of Harare in central Zimbabwe. The Neoproterozoic Makuti, Rushinga and Sijarira Groups are metasedimentary successions in the northwest of the country.

Non-marine Carboniferous to Triassic sediments of the Karoo Supergroup unconformably overlie Precambrian rocks in two separate basins, in the northwest and southeast. Tillites, sandstones, mudstones and coal beds are part of the Karoo sequence. Extensive basalts in the northwest and southern parts of the country overlie these sediments. Aeolian sands cover large parts of western Zimbabwe.

Several Mesozoic and Precambrian alkali ring complexes and carbonatites have intruded the Precambrian and the Karoo.

AGROMINERALS

Phosphates

Zimbabwe has a well-developed indigenous phosphate industry. All of the known phosphate resources are either of igneous provenance, associated with carbonatites, or guano. There are no known sedimentary phosphates in the country. The distribution of carbonatites and bat guano occurrences is shown in Figure 2.22.

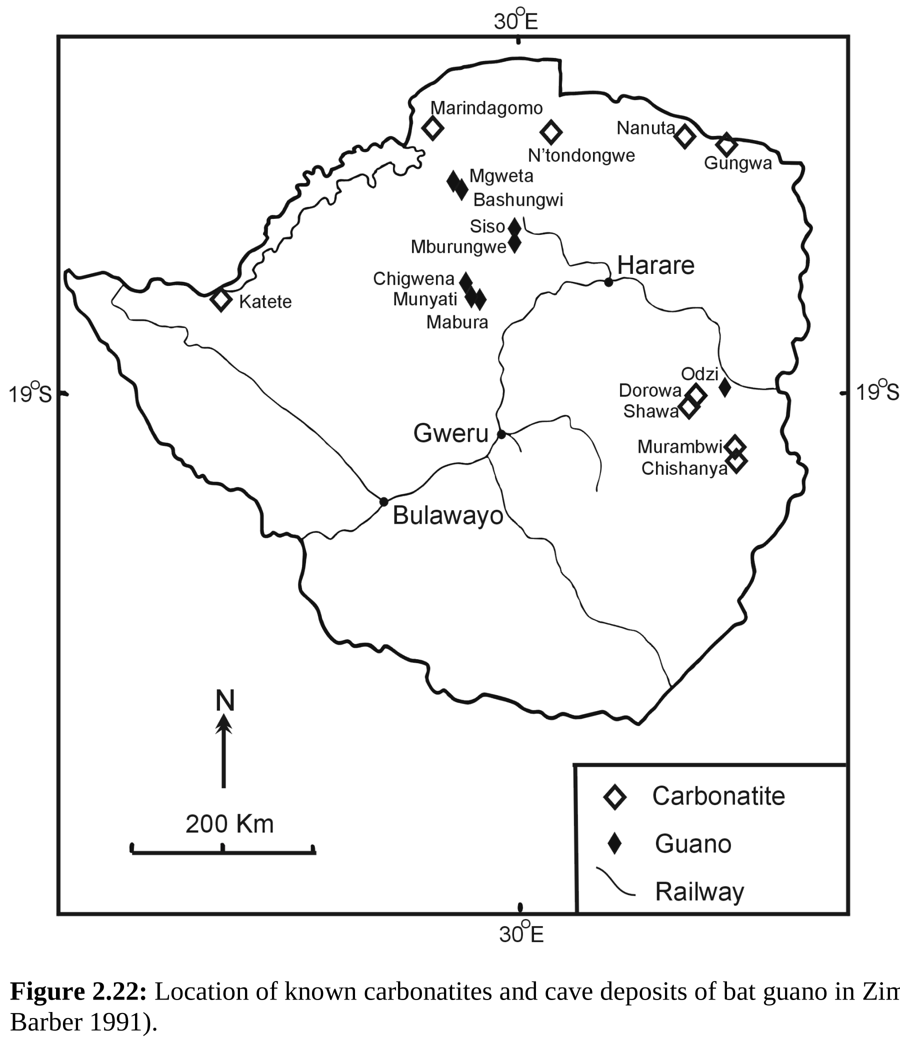


Figure 2.22: Location of known carbonatites and cave deposits of bat guano in Zimbabwe (after Barber 1991).

Barber (1991) reports 12 structures with lithologies that are considered to be carbonatites. Four of these structures are Mesozoic carbonatites and two of the 'probable' carbonatites are Precambrian in age. Little information is available from the other six recently discovered 'carbonatites' (Barber 1991). From the four Mesozoic carbonatites (Dorowa, Shawa, Chishanya, and Katete), only the Dorowa deposit is mined for phosphates at present.

1. The Dorowa carbonatite:

The Dorowa phosphate mine is located in the Buhera District along the tarmac road from Nyazura to Murambinda at 19^o04'S; 31^o46'E. Dorowa is a carbonatite with associated foyaite, ijolite and pulaskite rocks surrounding it (Barber 1991). The actual calcium carbonate plug forms only a very small portion of the complex with larger parts of the carbonatite likely occurring beneath the present surface level. The central nepheline-rich foyaites and ijolites have been extensively mineralized with phlogopite/vermiculite and apatite.

According to the phosphate mining company Dorowa Minerals Ltd., the total measured resources are 72-78 million tons at 6.56% P_2O_5 (Barber 1991). At present, the northern ore body is mined. Ore excavation and processing rates are 3,000-3,500 tonnes per day. The ore is upgraded from 6.5% to 35-36% P_2O_5 at the mine site through crushing, sieving, magnetic separation and flotation. Over the last ten years, the Dorowa phosphate mine has produced an annual average of 1,128,300 tonnes of ore (Fernandes 1995), yielding 132,000 tonnes of concentrate at 35.2% P_2O_5. In the year 2000, production decreased slightly to 125,000 tonnes of concentrate at 37% P_2O_5 (Chitata, pers. comm. April 2001). The phosphate concentrate is transported by road and rail to Msasa/Harare, where it is converted by acidulation processes to SSP and TSP. The price of the Dorowa phosphate rock concentrate (DPRC) at the mine site in Dorowa is US $37.26 per tonne (Fernandes 1995).

Fernandes (1978) and the International Fertilizer Development Center (IFDC) carried out detailed mineralogical investigations on phosphate samples from Dorowa. The apatite was identified as hydroxy-fluor-apatite. The neutral ammonium citrate solubility of the phosphate concentrate is very low, 0.8% P_2O_5.

Agronomic Testing of Dorowa Phosphate Rock Concentrate

Several agronomic experiments have been conducted using Dorowa Phosphate Rock Concentrate (DPRC). As predicted, the DPRC in its unmodified form has little agronomic effect when applied directly to the soil due to its low reactivity. However, partially acidulated DPRC and pelletized and compacted phosphate blends have shown good agronomic response (Govere *et al.* 1995; Dhliwayo 1999). As part of the Zimbabwe-Canada agrogeology project, supported by the International Development Research Centre (IDRC), the DPRC was pelletized in a locally developed, low-cost disc pelletizer, as well as compacted with various organic and inorganic materials. The materials used for the phosphate blends include various amounts of DPRC and triple superphosphate (TSP), as well as manure and an agricultural waste product, castor cake (Dhliwayo 1999). Research results from greenhouse and field experiments using maize and pigeon peas indicate that compacted phosphate blends performed slightly better than the less expensive pelletized blends. Modified DPRCs performed considerably better than the control and the directly applied unmodified DPRC.

Farm research with phosphorus rock-enhanced manures are ongoing as part of the Zimbabwe-Canada agrogeology project. The DPRC-TSP-blended pellets added to the manure act not only as source of phosphorus but also lower the pH in the manures to a degree that nitrogen losses are reduced. Farmers then apply the manures in the traditional way. Agronomic testing of pelletized DPRC on maize and other crops continues on farms in the Buhera region, in the immediate vicinity of the Dorowa phosphate mine.

2. The Shawa alkaline complex:

The Shawa alkaline ring complex, located in the Buhera District in east-central Zimbabwe (19^o 31'S; 31^o 43'E), is a 209 ±16 million year old, circular alkaline complex, approximately 5 km in diameter. Serpentinite and olivine-bearing dunite form the central part of the alkali ring structure. These rocks are in turn intruded by carbonatite.

The thick residual soils in the centre of complex are phosphate rich, derived from weathering of the carbonatite. Phosphate resources of the residual soils were calculated to be 20.3 million tonnes grading 10.8% P_2O_5, plus a further 2.7 million tonnes at 16% P_2O_5. Resources with low carbonate content, suitable for the existing flotation process at Dorowa, are estimated 16.3 million tonnes at 10.4% P_2O_5, 32.5% Fe_2O_3 and 0.8% CO_2 (Barber 1991). No detailed mineralogical characterization and agronomic testing of these phosphate resources have been carried out as yet.

3. The Chishanya carbonatite:

The Chishanya carbonatite complex in eastern Zimbabwe, at 19° 45'S; 32° 18'E, is a lower Cretaceous, 127 million-year old carbonatite complex with an approximate width of 1.5 km and a length of 5 km. The carbonatite is largely made up of coarse crystalline Ca-carbonatite (soevite). The surrounding hills contain lenses of late-stage dark brown Fe-carbonatite, rich in magnetite and apatite. The northern part of this complex was estimated to contain 1,600 tonnes of ore per metre depth with an average grade of 8% P_2O_5. Selective mining of the 2-3 m wide apatite-rich dikes at Baradanga Hill has been considered (Barber 1991).

No detailed characterization of the phosphate-rich ore has been carried out. Also, no agronomic testing has been conducted with this phosphate resource.

4. The Katete carbonatite:

The Katete carbonatite, 50 km northeast of Hwange (18° 09'S; 26° 53'E) in the northwest of the country, intruded into sediments of the Karoo Supergroup. Phosphates at Katete occur in the form of monazite, not apatite. The phosphorus content in the primary and secondary environment is low, ranging from 0.1 to 1.19% P_2O_5.

Guano

In Zimbabwe, bat guano is not classified as a mineral under the Mines and Minerals Act. The title of ownership of the bat guano is with the landowner. However, the marketing is controlled by the Fertilizer Act, which states that bat guano shall contain at least 2.5% N and at least 8% of N and P_2O_5 combined (Barber 1991). There are several caves with bat guano in Zimbabwe and the majority of the deposits lie in or adjacent to areas of subsistence farming or small-scale commercial farms. Barber (1991) considered them as ‘potential sources of possibly inferior, although still highly beneficial, phosphate-rich fertilizers suitable for direct application.’ Potential health problems related to the mining of bat guano are associated with the respiratory fungal disease of *Histoplasmosis* (inhalation of spores from *Histoplasma capsulatum*).

Most of the bat guano caves in Zimbabwe are found in the Lomagundi dolomitic marbles and limestones:

- near Bashungwi in the Rengwe Communal Land, Hurungwe District (Bashungwi guano caves),
- north of Chemvuri River on Murison Ranch (Chigwena guano caves),
- in the Zhombe Communal Land in Kwekwe District (Mabura-Vusa Emtoto caves),
- near the Chitomborgwizi small-scale farming area of the Makonde District (Mburungwe guano caves),
- on the northern bank of the Musuki River in the Hurungwe Communal Land, Hurungwe District (Mgweta guano caves),
- on the Munyati River in the Gokwe Communal Land in Gokwe District (Munyati River guano caves).

The only bat guano caves outside the Lomagundi dolomites are the caves in the Odzi area, in Bulawayan marble along the Odzi Greenstone Belt (Barber 1991).

Reserves of bat guano are difficult to establish due to the irregular nature of the cave floor and the presence of concealed blocks. The Mabura guano caves for example supposedly contain 2 million tonnes, but the figure is disputed by Barber (1991). The Mgweta Hill guano reserves are conservatively estimated at over 2,700 tonnes. As a general rule, the surface layers are richer in nitrogen and the underlying layers are richer in phosphate. For example, the Mabura guano deposit contains 9.26% N and 7.53% P_2O_5 near the surface and 0.49% N and 14.99% P_2O_5 at a depth of 3.7-5.0 m (Barber 1991).

In total, the resource base of these non-mineralic fertilizer materials is low and limited. Only small tonnages of cave guano can be excavated. Persons extracting cave guano should have their health monitored regularly to avoid contamination with *histoplasmosis.*

Liming material

Barber (1991) provides a detailed account of 248 limestone and dolomite occurrences in Zimbabwe. Numerous marble occurrences are reported from the Archean greenstone belts, especially from the Bulawayan Group (Barber 1991; Gwosdz 1996). They are clustered around Harare, Gwanda, and Gweru. Some of these large marble deposits are mined and processed for the cement industry (for instance Sternblick quarry for the cement industry in Harare, and Colleen Bawn, south of Gwanda for the cement industry in Bulawayo). Dolomite deposits in the Paleoproterozoic Lomagundi Group are extensive in the Kadoma and Chinhoyi areas. Some of the dolomitic marbles, for instance at Tengwe, 100 km northwest of Chinhoyi, are used for road construction and for agricultural purposes ('agricultural lime'), specifically in tobacco and maize growing areas. The volume of these dolomites is enormous, the 180 m thick dolomites at Tengwe cover an area of more than 130 km^2.

Smaller amounts of impure limestones are reported from Karoo sediments in the Hwange area and 80 km west of Kadoma.

Calcium and calcium-magnesium carbonates are part of the Chishanya and Shawa carbonatites. The carbonates in the Dorowa carbonatite are negligible.

Calcrete hardpans have been reported from the Hwange area and around Gwanda. Some of this calcrete has been used for road construction (near Hwange) and the production of quicklime.

Travertine deposits occur east of Shamwa, near Birchenough and Tengwe and some of these deposits have been used for the production of quicklime (Gwosdz 1996).

In Zimbabwe, carbonate rocks are used for many industrial and agricultural purposes, including the cement, metallurgical and construction industry. Production of agricultural liming materials, made up of ground, uncalcined limestone and dolomite, as well as slaked lime is high. According to the Central Statistical Office, the total consumption of agricultural liming agents was 55,000 tonnes in 1981, and 43,000 tonnes in 1983 (Barber 1991).

Preliminary figures of recent production indicate that the production of uncalcined limestone is in the range of a several tens of thousands of tonnes, and calcined lime is in the range of 10-20,000 tonnes. Some of the lime is produced as a co-product by the cement industry. In other operations it is recovered for the sole purpose of agricultural lime production, for example the Early Worm operation. Production data from Circle Cement indicate 1998 sales of approximately 17,800 tonnes uncalcined limestone. Their 1999 production was approximately 25,000 tonnes. Another company, G&W Minerals (which includes the Early Worm and Chegutu Stone operations) produced 39,000 tonnes 'ag-lime' in 1999. Approximately 40% of this production was calcined (G&W, pers. comm. March 2000).

Amending acid soils with limestone/dolomite or agricultural lime is common on many farms in Zimbabwe. Application rates vary between 1 tonne and several tonnes per hectare.

Sulphur/sulphides

There are considerable sulphide deposits in Zimbabwe, mainly associated with base metal and gold deposits. The only sulphide source mined for the sole purpose of providing sulphur for sulphuric acid production is the Iron Duke pyrite mine, 45 km north of Harare. This underground mine produces pyrite ore containing 35.5% S (Barber and Muchenje 1991). General annual production rates of pyrite over the last 40 years have ranged between 50,000 and 70,000 tonnes with 71,026 tonnes produced in 1994 and 70,760 tonnes in 1995. Approximately 85% of the pyrite is supplied to ZIMPHOS Ltd. at the phosphate fertilizer plant in Msasa/Harare to produce sulphuric acid for the acidulation of phosphate rock from Dorowa (Barber and Muchenje 1991). In 2001, the Zimbabwe fertilizer company ZIMPHOS will export 51,000 tonnes of sulphuric acid to the Zambian copper industry (Sunday Mail, April 4, 2001).

Investigations of the hydrochemistry of the tailings and tailings effluents at the Iron Duke mine showed extremely low pH levels (down to pH = 0.52) and toxic concentrations of Al, Cd, Zn, Cu, Cr, Ni, V and As in the drainage waters (Williams and Smith 2000).

Vermiculite

Two vermiculite mining companies (Samrec Vermiculite, and Dinidza Vermiculite Mining Co.) operate at the Shawa alkaline complex in Buhera District (see section on phosphates). The vermiculite ore is formed as a weathering product of the underlying phlogopite and biotite-rich mica pyroxenite. Production of vermiculite from both mines for the mainly international market was 14,841 tonnes in 1997 (according to the British Geological Survey World Mineral Statistics). Samrec Vermiculite (Zimbabwe) (Pvt) Ltd. will increase production to approximately 40,000 tonnes per year in 2001/2002 (Industrial Minerals, Sept., 2001).

The coarse vermiculite is exported overseas for use in the construction and horticultural industries. Approximately 30 tonnes of fines, smaller than 250 microns in size, are discarded every day as ‘waste’ although some of these fines are collected by Zimbabwean and South African customers for use as animal feed additives (Nyamuswa, pers. comm. April 2001).

Rock and mineral wastes

Phospho-gypsum, a waste product from the phosphate fertilizer industry in Msasa near Harare, is currently stockpiled. In 1999, the total volume of the phospho-gypsum tailings exceeded 920,000 tonnes (Mashingaidze, ZIMPHOS Ltd., pers. comm. May 2000). Part of the phospo-gypsum ‘waste’ is used by the local wallboard industry, part is exported to Malawi for use in the cement industry and for agricultural use, specifically for fertilizing groundnuts.

During investigations of the phosphate tailings at Dorowa, eight million tonnes of ‘waste’ vermiculite were ‘discovered’ by the Zimbabwe-Canada agrogeology project. Detailed studies on these waste resources and their potential use are ongoing.

Several million tonnes of rock waste of basaltic composition are currently discarded in the Mutoko area near Nyamazuwa, where ‘black granite’ is extracted from Mashonaland gabbro/dolerite deposits. In 1999, Zimbabwe produced 143,000 tonnes of black granite (Maponga and Munyanduri, in press). During extraction of the black granite blocks, some 80-90% of the rock goes to ‘waste.’ Early agricultural trials with heavy applications (5-40 tons per acre) of ground basaltic rock on Kalahari sand in Zimbabwe showed increased crop yield (Roschnik *et al.* 1968).

Until recently, Dorowa Minerals Ltd. discarded approximately 8 tonnes of phosphate fines daily from its drying operation. Some of this wasted 'dust' was used in compacted and phosphate-TSP blends by the Zimababwe-Canada agrogeology project.

Agromineral potential

The potential for development of the agromineral resources of Zimbabwe is good. The indigenous fertilizer industry of Zimbabwe already provides most of the raw materials for modern farming practices, but the potential to develop alternative low-cost phosphate fertilizers is also good. With an operational phosphate mine that already produces inexpensive PR concentrates, developing low-cost and agronomically effective phosphate blends for communal and small-scale farmers is a practical proposition. Experiences from the Zimbabwe-Canada agrogeology project indicate that Dorowa phosphate concentrate and phosphate fines currently disposed of as 'wastes,' can be pelletized or compacted with already existing superphosphates or with other nutrients and nutrient-containing 'waste products' to form low-cost alternative fertilizers and soil amendments. Finely ground dolerite/gabbro 'wastes' from the numerous 'black granite' operations should be tested on nearby soils to assess their potential to improve the soil fertility in local community gardens and fields, especially for perennial crops and trees.

Locally available agricultural lime needs to be tested by communal and small-scale farmers on acid soils. Phospho-gypsum from the phosphate plant near Harare should increasingly be used in groundnut production by all farmers. Alternative uses of phospo-gypsum in agriculture (Mays and Mortveldt 1986) and alternative further processing of this 'waste,' for instance, by the Merseburg process (Burnett *et al.* 1996) should be envisaged.

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